PREDATION ON BUTTERFLIES AND OTHER INSECTS BY BREEDING RAINBOWBIRDS (*MEROPS ORNATUS*: MEROPIDAE) IN SOUTH-EAST QUEENSLAND

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Abstract

The diet of a family of Rainbowbirds (*Merops ornatus* Latham) nesting in the Currimundi Environmental Park, southern Queensland, was investigated over approximately four months. Three birds were involved, a breeding pair and a helper male. Insect prey was monitored photographically with 836 items being recorded. The recorded diet of the adults before hatching and that brought to the nestlings differed considerably, with Hymenoptera being the most important adult prey class for adults, both numerically and in terms of biomass. However, few honeybees (*Apis mellifera* Linnaeus) were eaten by adults. Conversely, the most important components of the nestling diet in terms of biomass were cicadas, dragonflies (Anisoptera) and various Diptera. Large numbers of honeybees were also brought to the nestlings during their later development, particularly by the female bird and these comprised almost all the Hymenoptera fed to the nestlings. Lepidoptera, chiefly butterflies of all families, formed a minor but conspicuous part of the diet, particularly of the adults. Relatively fewer were fed to the nestlings, possibly because of the abundance of cicadas and dragonflies in the foraging territory.

Introduction

Some of the most voracious predators of aerial insects are the Bee-eaters of the family Meropidae (including the genera *Merops*, *Nyctyornis* and *Meropogon*), which inhabit the old world tropics and warm temperate regions. *Merops ornatus* Latham, also known as the Rainbowbird (Fig. 1), is found throughout much of Australia, where it breeds in long tunnels excavated in flat ground or in the vertical faces of river banks and in coastal dunes (Fry 1984, Higgins 1999). It overwinters mainly in New Guinea and possibly on islands further west, thus ensuring a continuous supply of insect food during the Australian winter or tropical dry season. When not nesting, the birds travel in nomadic groups and are difficult to observe closely but, when nesting, breeding pairs and often one or more helpers confine their activities to a small territory around the nest. They rapidly habituate to a human observer, allowing close visual monitoring of their insect diet.

There has been only limited study of the diet of the Rainbowbird. The Honeybee, *Apis mellifera* Linnaeus, is not native to its range but often forms a large proportion of prey taken, especially around apiaries, where the birds are regarded as pests and are often shot (McKay 1969). On the other hand, one report from Victoria claimed that dragonflies (Odonata) supplied the greatest biomass of food consumed, although they were numerically fewer than other forms of prey (Fry 1984). Another study reported that larger prey items were selectively taken to the nest to feed the growing chicks (Fry 1984). Conversely, Calver (1987) reported nestling Rainbowbirds feeding mainly on Hymenoptera. Lepidoptera reported as casual prey items include *Vanessa cardui* (L.) (= *kershawi* (McCoy)), *Vanessa itea* (F.), *Zizina*

labradus (Godart) and species of Noctuidae (Higgins 1999). Draffan *et al.* (1983) reported migrating Rainbowbirds consuming large numbers of *Eurema hecabe* (L.) before making the journey across Torres Strait to New Guinea. Additional records of prey captured (but not necessarily eaten) found on internet images include *Arhopala centaurus* (F.). *Belenois java* (L.) and *Tirumala hamata* (W.S. Macleay).

Rainbowbirds breed regularly in horizontal tunnels in the banks of the northern shore of Currimundi Lake and along the beachfront dunes in front of the Currimundi Lake Conservation Park (26°46'12"S, 153°7'19"E). This habitat island is a fully protected area of 52 ha of 'Wallum'. It comprises a complex association of vegetation types including stunted, fire-climax heath with exceptionally high plant diversity and stands of low *Casuarina*, *Banksia* and *Melaleuca*. To seaward it is bordered by a narrow, low rainforest-like association in the swale behind the sand dunes facing the Pacific Ocean to the east. Elsewhere, the park is bounded by the salt water Currimundi Lake to the south and dense suburban areas on its northern and western sides. During the breeding season of 2012, I observed the birds closely and regularly, recording their social behaviour and the range of insect prey consumed.

Area, breeding chronology of birds and methods

From early September 2012 to 6 January 2013, I was able to monitor one nesting family of Rainbowbirds consisting of a breeding pair and a helper male. The two males could be separated by slight differences in the symmetry of their streamers, visible in most photographs. They occupied a territory approximately 6 ha in area, including both shores of Currimundi Lake (Fig. 2). To the east and north their territory abutted those of other breeding groups. Upon arrival, an existing tunnel in a small embayment on the northern bank of the lake was refurbished, chiefly by the female, until its final depth was 1.25 m. Several other false tunnels up to 0.35 m long were constructed or refurbished nearby. Foraging activity was coordinated from an observation perch *ca* 10 m high and *ca* 30 m from the nest entrance. Birds returned there to eat their prey or, if intended for the nest, to subdue it. When prey was brought to the nest, the birds almost always first perched at least for a few seconds on a low 'nest perch' *ca* 4 m from the nest. Almost all prey items were photographed when the birds were on the observation perch or the nest perch using a 70-300 lens mounted on a Nikon D90 DX format SLR camera. In total, *ca* 18,000 photographs were taken. It was possible to identify all butterflies, most cicadas and all Odonata prey to genus or species and all other groups at least to family, with the exception of a few smaller Hymenoptera. Average biomass estimates of all common prey species were made by weighing fresh killed specimens, collected outside the reserve, on a milligram balance. When no specimens were available, biomass was estimated by comparing their linear measurements, easily assessed relative to the length of the birds' bills (27-28 mm), with those of known species.

Fig. 1. Rainbowbirds with prey: (a) helper male on the nest perch with a female *Ogyris zosine*; (b) female in flight taking cicada to nest.

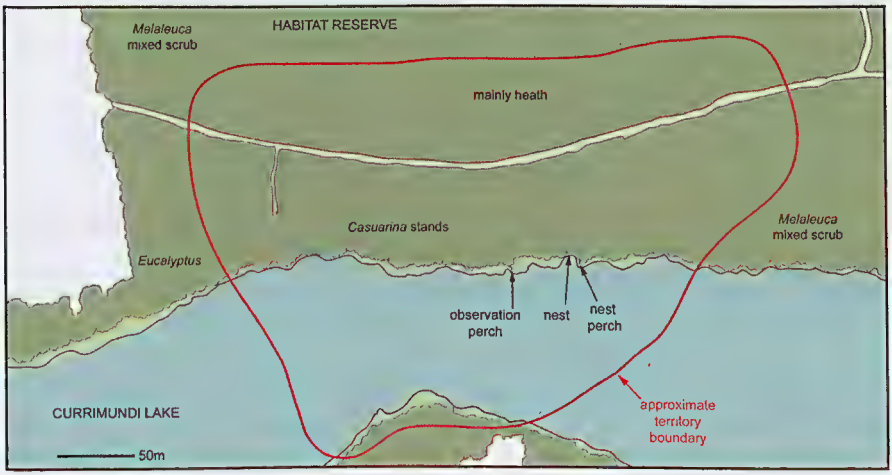

Fig. 2. Map of study area showing salient features.

Throughout September and October, the birds were monitored in the vicinity of the main perch and at other favoured perches around the territory for at least 30 minutes on most days. Any prey taken was recorded photographically. On 3 November, courtship feeding was recorded when the breeding male presented the female with a moth, ?*Ophiusa disjungens* (Fig. 3) and a tabanid fly. Judging from the time the female spent in the burrow, egg laying probably commenced on 7 November, continuing over several days. Presumably four eggs were laid as four fledglings later appeared with no evidence of any egg or chick mortality. Brooding was shared by the female and at least one of the males, probably chiefly the helper. The helper male soon broke his streamers, greatly facilitating individual recognition. It was inferred from the behaviour of the birds that the first hatching occurred on or around 1 December, which suggests an incubation period of 21 days, similar to the figure reported by Boland (2004). Boland (2004) also reported asynchronous hatching. From the time of laying, observations in the vicinity of the nest were increased to one hour per day and later, after hatching, to two daily one-hour observation periods morning and afternoon. The chicks fledged between 1 and 5 January 2013 and on the morning of 6 January all birds disappeared.

Results

Overall

The total number of individuals and biomass representation of different orders of insects recorded as captured and eaten at either the main perch or at other perches around the territory is shown in Table 1. Of 167 items recorded, Hymenoptera were clearly the preferred prey, followed by Diptera, especially Tabanidae. Only three honeybees were recorded among the prey. Lepidoptera comprised only 8.4% of individuals and 6.5% of biomass. Most prey items had a wet mass of >50 mg, although in a few cases smaller insects were observed taken and swallowed on the wing. Presumably, smaller items do not justify the expenditure of energy involved in their capture.

Table 1. Breakdown of prey items taken and eaten before hatching of eggs.

	individuals	percent individuals	biomass mg	percent biomass
Hymenoptera	107	64.1	8560	50.0
Diptera	22	13.2	2640	15.4
Lepidoptera	14	8.4	1120	6.5
Coleoptera	9	5.4	630	3.7
Cicadidae	4	2.3	1250	7.3
Odonata	8	4.8	2310	13.5
Other	3	1.7	600	3.5
TOTAL	167		17110	

Fig. 3. (a) female Rainbowbird tossing *Junonia villida* with her mate alongside; (b) breeding male giving female a nuptial gift (?*Ophiusa disjungens*) just before breeding; (c) helper male on nest perch with battered *Junonia villida*; (d-e), the same battering *Junonia villida*.

Conversely, larger items such as dragonflies, cicadas and some butterflies generally involved considerable handling time, lasting 150 seconds in one case of *Graphium eurypylus* (L.) (Fig. 4). Typically, the bird perched on a

thick branch near the main perch and repeatedly bashed the insect's head against it with a characteristic twist of the (bird's) head, which meant that it was often turned upside down at the moment of impact. The stunned insect was several times tossed into the air and caught before being swallowed head first, wings and all (Fig. 4), with harder parts eventually regurgitated as a pellet. Such pellets accumulated in large numbers under the main perch.

Table 2 shows the same statistics for prey taken to the nest after hatching. A total of 669 items was recorded. During this period many insects were also observed being eaten by the providers, including two butterflies, but their number was much fewer than the number of prey items taken to the nestlings. Because observations were concentrated mainly on the nest, it is considered that these records are not comparable with either pre-hatching feeding records or with nest provisioning rates; hence they are not included in the general analysis.

Table 2. Breakdown of prey items captured and taken to feed nestlings after hatching.

	individuals	percent individuals	biomass mg	percent biomass
Hymenoptera	178	26.6	15130	8.8
Diptera	146	21.8	21906	12.8
Lepidoptera	24	3.6	2200	1.3
Coleoptera	3	0.5	240	0.1
Cicadidae	213	31.8	103850	60.5
Odonata	87	13.0	24270	14.1
Other	18	2.7	3960	2.3
TOTAL	669		171556	

The range of prey taken to the nestlings differed greatly from the adult diet, with cicadas, especially *Psaltoda harrisii* (Leach), *Tamasa tristigma* (Germar) and *Cicadetta* sp. accounting for more than 30% numerically and 60% of biomass. Significant biomass was also contributed by Odonata, mainly *Adversaeschna brevistyla* (Rambur) and *Hemicordulia* sp. and by Diptera, including *Apiocera* sp. (Apioceridae), *Rutilia* sp. (Tachinidae), Tabanidae and a few Asilidae. Hymenoptera were far less important in the diet and almost all were honeybees, brought to the nest principally by the female between 1400-1600h, starting when the nestlings were about 15 days old. At first she brought devenomed individuals, then dead but intact specimens, then, just before fledging, living bees. At times she brought honeybees to the nest at a rate of almost one per minute, sometimes impeding the helper male in his efforts to deliver food. It is tempting to interpret these bouts of honeybee provisioning as educational, designed to teach the young to cope with venomous Hymenoptera after they leave the nest. The helper

Fig. 4. Helper male tossing and swallowing a male *Graphium eurypylus* on a thick 'anvil' branch behind the main perch.

male also brought a few bees, mainly devenomed, towards the end of the chicks' development.

Lepidoptera

Lepidoptera generally made up a relatively small proportion of the diet with just 14 taken prior to hatching, 24 taken to the nest and 2 eaten during the nest provisioning period. All butterfly families were represented and there were just two moths, one Erebidae and one Noctuidae (following Zahari *et al.* 2012). Lepidoptera formed a significantly smaller proportion of the nestlings' diet than that of adult birds ($P<0.01$ test of proportions). Table 3 shows all Lepidoptera captured, a range of which are illustrated in Figs 5 and 6, and the individual birds which took them. The greater number taken by the female probably reflects the fact that she was most active in provisioning the nest overall. Conversely, the breeding male caught only four lepidopterans, one given to the female before courtship, one taken to the nest just before fledging and two eaten before breeding. Overall, the breeding male took relatively few items to the nest, but once chicks were fledged they stayed very close to him, watching his hunting sallies closely. They begged and were fed by him.

Table 3. Total of all Lepidoptera taken by each bird during the study, including items eaten and items fed to nestlings.

PREY	female *Merops ornatus*	helper male *Merops ornatus*	breeding male *Merops ornatus*
Trapezites symmomus	6	1	
Ocybadistes ?walkeri		1	
Telicota ?colon	1	1	
Cephrenes augiades	5		
Graphium eurypylus		2	
Graphium sarpedon	2		
Catopsilia pomona	2		1
Junonia villida	3	2	2
Vanessa itea	1		
Ogyris zosine	3	2	
Theclinesthes miskini		2	
Nacaduba berenice		1	
?Ophiusa disjungens			1
?Spodoptera sp.		1	
TOTAL	23	13	4

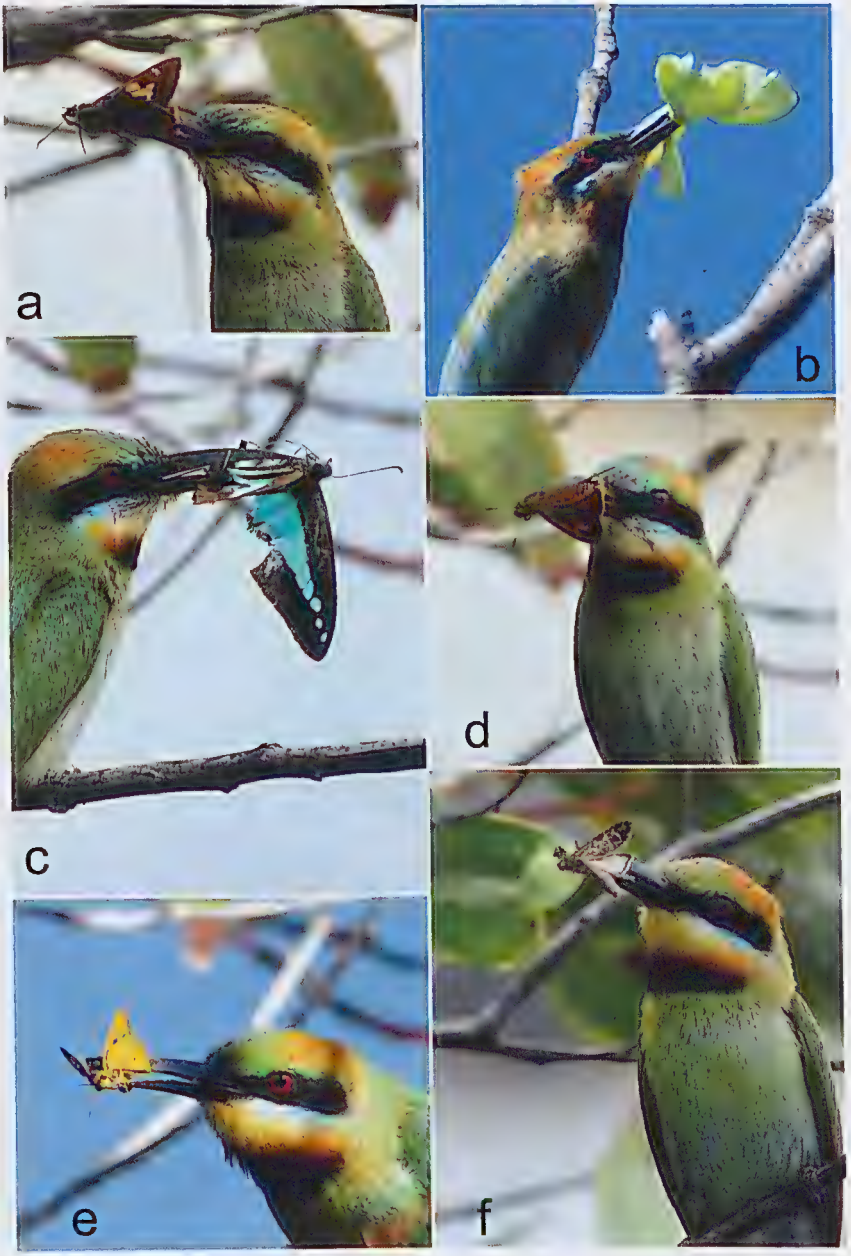

Fig. 5. Range of Lepidoptera prey: (a) *Trapezites symmomus*; (b) *Catopsilia pomona*; (c) *Graphium sarpedon*; (d) *Cephrenes augiades*; (e) *Telicota ?colon*; (f) *?Spodoptera* sp.

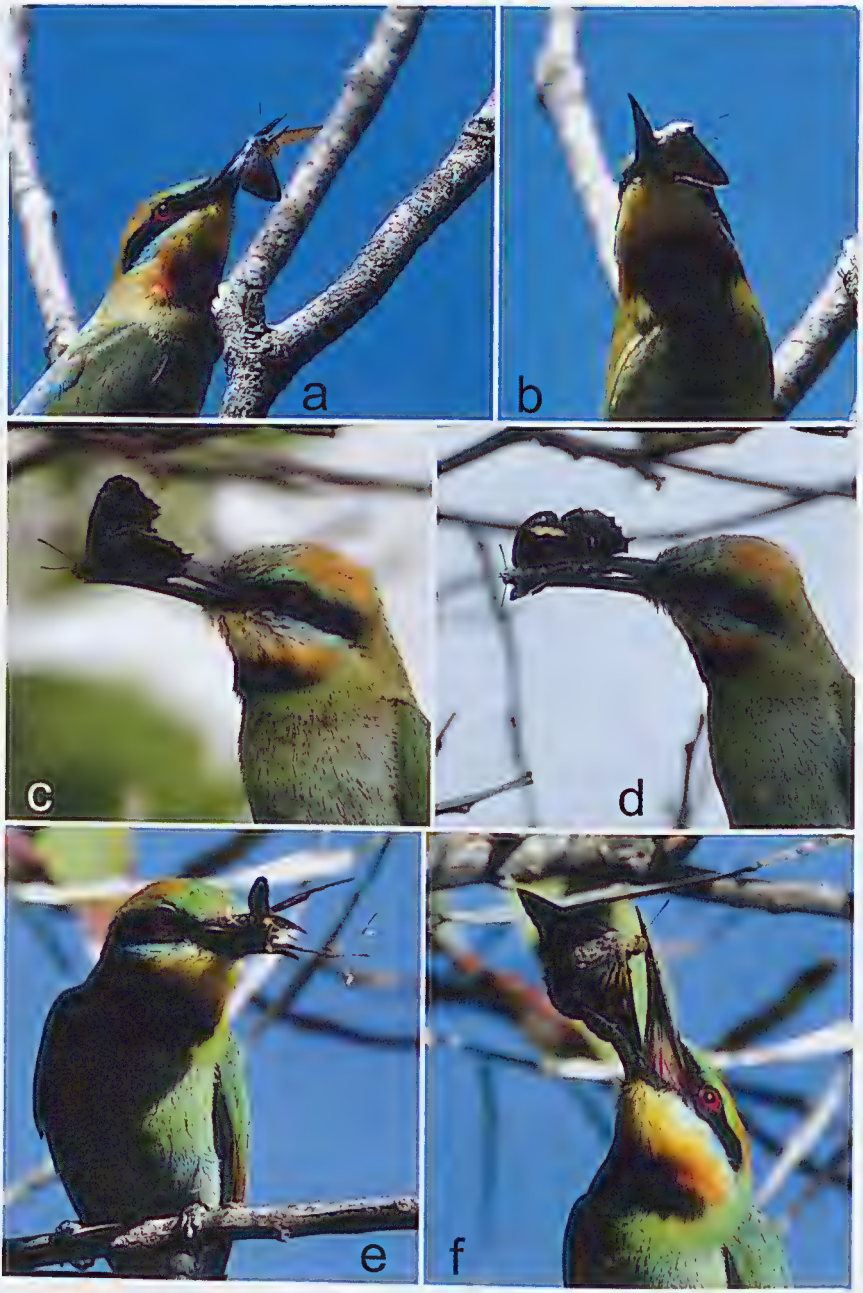

Fig. 6. Range of Lepidoptera prey: (a) *Nacaduba berenice*; (b) *Theclinesthes miskini*; (c) *Ogyris zosine* male; (d) *Ogyris zosine* female; (e) *Cephrenes augiades* shattering as bird crushes it with its bill; (f) tossing *Cephrenes augiades*.

When the nestlings were newly hatched, prey was thoroughly processed before being taken to them. The wings of dragonflies were removed, while butterflies were pulverised and their wings removed as far as possible, to the point where they were unrecognisable (Figs 3 c-e). After about ten days, dead but otherwise intact butterflies were fed to the chicks.

Discussion

Rainbowbirds are opportunistic predators that are said to always take their prey on the wing (Fry 1984). Although they are clearly behaviourally adapted to catch and process venomous Hymenoptera, other groups such as Diptera, Odonata (Orr 2013) and cicadas can obviously represent an important food source when available. Lepidoptera in this case were of less importance, but this may have reflected their relative availability. Also, with their broad wings they may create more problems with handling and swallowing then other larger insects such as dragonflies and cicadas. Nevertheless, the present study documents predation on 12 species of butterfly, only one of which, *Vanessa itea*, is recorded in literature. Thirty-four percent of these are hesperiids, which with their stout bodies and narrow wings may offer a better nutritional return versus handling effort than other species. Also, as far as is known, all local hesperiid species are palatable to vertebrates.

It is of interest that *Delias argenthona* (F.), one of the commonest butterflies present throughout the study, often flew close to the main perch but was never attacked or even looked at. It has been established that *Delias nigrina* (F.) possess emetic properties that are effective against some birds (Orr 1999, Orr and Kitching 2010) and very probably the same is true of *D. argenthona*.

Other reasonably common species ignored included *Euploea core* (Cramer), *Tirumala hamata* and *Papilio aegeus* Donovan. The first two are generally thought to be toxic or unpalatable due to cardeneloids and/or pyrrholozidine alkaloids, gained respectively from their asclepiadaceous and apocynaceous host plants (Ackery and Vane Wright 1984). As noted above, a photograph on the internet shows a Rainbowbird with a *T. hamata* in its bill, but this is not conclusive proof that it swallowed it. *Papilio aegeus* is probably only moderately palatable but the size of its wings would necessitate much handling before it could be swallowed. Evidence that size may be a deterrent comes from an aborted attack on a *Polyura sempronius* (F.), first sighted about 40 m away; the female bird had swooped on the butterfly from behind, but at the last moment pulled away. *Belenois java* is probably only moderately palatable (see Turner 1984 for discussion of the palatability spectrum) and, as with *T. hamata*, there is a photograph of one in the bill of a Rainbowbird on the internet. Again, this does not prove it was consumed. In November, *B. java* adults were extremely abundant for about four days but elicited no interest from the birds. However, as they were only briefly present it is possible the birds were unwilling to attack them because of their unfamiliarity.

Once the chicks had fledged they remained close by a parent, typically their father. Every foraging flight by the adult bird was closely watched and, after a few days, the young attempted to catch insects themselves, generally with indifferent results. When one observes how closely the young birds watch their parents foraging, it seems possible that avoidance of putatively distasteful or toxic species such as *Delias* may be learned culturally, without any experimentation by naive birds as is usually supposed. It is also of interest that, although *Ogyris zosine* (Hewitson) shares the same food plants as *Delias argenthona*, it clearly is palatable to Rainbowbirds. No doubt the sequestration of toxic compounds from a host plant depends on the physiology of each species and may vary within species.

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